

APPLICATION FOR
UNITED STATES LETTER PATENT
SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that I, Edward G. Osborne, a citizen of Canada, and resident of Lachine, Quebec, Canada, having a postal address of 110 55th Ave., in the City of Lachine, Province of Quebec, Canada H8T 3B2, have invented new and useful **“ELECTRIC CHARGE DETECTOR”**, of which the following forms the specification.

“ELECTRIC CHARGE DETECTOR”

CROSS REFERENCE TO RELATED APPLICATIONS

Not applicable.

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STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

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REFERENCE TO MICROFICHE APPENDIX

Not applicable.

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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to an electrical device. More particularly the present invention relates to a device for detecting an electrostatic charge on an object and alarming on the potential for electrostatic discharge. An additional action taken on sensing high potential for electrostatic discharge is the use of a positive or negative ion generator to remove the built-up charge.

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Background Art

Electrostatic discharge between a body or object and an electronic device, such as a circuit board, can damage or destroy the electronic device. Electrostatic discharge can be very dangerous when it occurs during the process of filling a motor vehicle with gasoline, in the vicinity of the gasoline vapors. At other times, electrostatic discharge
5 may cause discomfort. Various devices are used to dissipate an electrostatic electric charge from a body, such as a wrist strap connected to a wire going to ground. Some devices initiate an alarm in the event of an electrostatic discharge. Other devices measure and alarm on static electric charge accumulation. Wilson, in U.S. 6,150,945 reveals a capacitance device for measuring a charge on a body. The device is not
10 grounded and uses a capacitor with a fixed capacitance. A charge accumulates on the fixed capacitance capacitor due to triboelectric processes. The signal, proportional to the charge on the device of U.S. 6,150,945, will tend to decay in magnitude over time due to the use of a high-impedance differential amplifier. This differential amplifier has a finite input resistance, and consequently, discharges the voltage on the very small
15 capacitance produced by a triboelectric charge event.

There is, therefore, a need for a method and device for measuring the electrostatic charge accumulation on a body or object and its potential for electrostatic discharge, all without the inconvenience of a connection to ground. There is a further need for a device for measuring static charge accumulation without causing the signal representing
20 the electrostatic charge to artificially dissipate. A further need is for a method and device for removing an accumulated electrostatic charge from a body or object.

BRIEF SUMMARY OF THE INVENTION

A purpose of this invention is to provide a method and apparatus for accurately measuring an electrostatic charge accumulated on a body or object; and, therefore, the potential for an electrostatic discharge between that body or object and another body or object having a different electrostatic charge and the capacity to change its electrostatic charge. Another purpose of the present invention is to provide a device for measuring electrostatic charge without dissipating the measured charge during the measurement. A further objective of the invention is to provide a method and apparatus for removing an electrostatic charge based on the electrostatic charge measurement results.

To measure a magnitude of electric potential with respect to ground, a capacitance of a conductor having a capacitance to ground is modulated in a periodic fashion. When the capacitance is modulated, the magnitude of the charges on this conductor also changes periodically. The amplitude of this periodic charge is proportional to the electric potential compared to ground.

To effect the above, a rotor is used, having a shape like two identical segments of a circular disk, symmetrical about a pivot point. The rotor oscillates at a fixed frequency about the pivot point with the aid of a torsion spring. One section of this rotor is one plate, or electrode, in the capacitor and oscillates behind a faraday shield in which a hole, or "window," is provided. During its travel, this rotor section will pass the window, at one point exposing the greatest surface area of the rotor to the window. It will also pass out of the window such that no part of this rotor section is exposed by the window. Any portion of this rotor section exposed by the window is exposed to the ambient. The electric charge detector experiences its lowest capacitance when this rotor section is completely hidden behind the faraday shield. When the maximum area of this rotor section is exposed to the window, the electric charge detector realizes its greatest capacitance. A second rotor section is an electrically separate conductor used as the movable part, or armature, of an electrostatic motor.

The result of the oscillation and variable capacitance is an Alternating Current (AC) signal, the magnitude of which is proportional to the electric potential applied to

the electric charge detector. This signal can also be shown to be proportional to the magnitude of the electrostatic charge potential between the body or object of interest and ground. The polarity of the charge may also be determined by this invention.

When a body or object reaches a threshold charge magnitude, the electric charge detector may be configured to provide an alarm. Such an alarm would be perceptible by one or more of the senses, thus audible, visible, tactile, etc. Another, optional reaction to the detection of an electrostatic charge greater than a predetermined threshold is the generation of positive or negative ions, depending on the sign of the accumulated electrostatic charge, to neutralize the electrostatic charge on the body or object.

The novel features which are believed to be characteristic of this invention, both as to its organization and method of operation together with further objectives and advantages thereto, will be better understood from the following description considered in connection with the accompanying drawings in which a presently preferred embodiment of the invention is illustrated by way of example. It is to be expressly understood however, that the drawings are for the purpose of illustration and description only and not intended as a definition of the limits of the invention.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Fig. 1 is a plan view of an electric charge detector of the present invention along with a schematic of associated electronics;

Fig. 2a is the same plan view as seen in **Fig. 1**, showing an orientation for **Fig. 2b**;

Fig. 2b is a side elevation view of the electric charge detector;

Fig. 3 is a time trace of five (5) AC signals;

Fig. 4 is the same plan view as seen in **Fig. 1**, showing a wire neutralization grid inside a faraday shield window;

Fig. 5 is a functional diagram of the electric charge detector with an optional ion generator;

Fig. 6 is a functional diagram of the electric charge detector without an ion generator;

Fig. 7 is a perspective view of the electric charge detector of the present invention mounted on a headband; and

Fig. 8 is a perspective view of the electric charge detector of the present invention mounted on a wrist band.

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DETAILED DESCRIPTION OF THE INVENTION

In the diagram of **Fig. 1**, the top edge view of a multiple-plate air capacitor is shown along with electronic function blocks and electrical connections; all comprising the electric charge detector **100**. A moveable plate in the capacitor which, the first
10 embodiment is a rotor **105**, is comprised of a first rotor section **105a** and a second rotor section **105b**, both approximately disk sections. The rotor **105** is suspended by a torsion spring (not shown) at its center of gravity **110** so the rotor can oscillate at a fixed, resonate frequency. As the rotor oscillates, it assumes a position behind a faraday shield **200** (**Fig. 2**) behind which the rotor **105**, and additional plates **115**, **120** reside
15 (for clarity, the faraday shield is not seen in **Fig. 1**). The first rotor section **105a** is the conductor having variable capacitance to ground. It is connected to the charge detector circuitry. The second rotor section **105b** is an electrically separate conductor which moves the rotor using electrostatic forces. When the first rotor section **105a** is completely hidden by the faraday shield **200**, the capacitance is at a minimum. As the
20 rotor **105** continues to oscillate, the first rotor section **105a** assumes a position exposed to the ambient via a window **125** in the faraday shield **200**. When the rotor is in this position, the capacitance is a maximum. Only the portion of the surface of the first rotor section **105a** exposed to the ambient via the window **125** in the faraday shield **200** participates in the capacitance of the first rotor section **105a**. Varying the exposure of
25 the first rotor section **105a** to ambient is analogous to varying the surface area of the first rotor section **105a**. The rotor **105** is shown halfway between these two extreme positions in **Fig. 1**, exposing a portion of a first rotor section **105a** to the ambient.

Five (5) AC signals: S1, S2, S3, S4, and S5 are depicted in **Fig. 3**. The abscissa is time. Each signal has an ordinate that is voltage. The first four (4) signals: S1, S2, S3, and S4 are generated in an AC signal generator **130**. Two signals, S1 and S2, are
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applied to a pair of additional plates, one lower plate **120a** and one upper plate **115a** respectively, while two more signals, S3 and S4, are applied to another pair of additional plates, one lower plate **120b** and one upper plate **115b**, respectively. The relative positions of the additional plates **115**, **120**, as well as the rotor **105** are depicted in **Fig. 2b**: additional plates **115a**, **115b** are above the rotor **105**, while additional plates **120a**, **120b** are below the rotor **105**. The AC signals, S1, S2, S3, and S4, induce resonate mechanical oscillations in the rotor **105** by electrostatic attraction to the second rotor section **105b**. The induction of a drive signal in the first section **105a** of the rotor, furthest from the additional plates **115**, **120**, via the second rotor section **105b** is minimized by charge balancing, as well as frequency doubling. The charge balance results from an upper additional plate **115a**, **115b** and its associated lower additional plate **120a**, **120b** having signals of equal amplitude and opposite polarity. Thus, the induced charges on the top and bottom surfaces of the second rotor section **105b** between these additional plates **115**, **120** are equal. Note that signals S1, S2, S3, and S4 have twice the frequency of the input signal, S5, to the phase detector **135**. The frequency doubling exploits the polarity insensitivity of electrostatic attraction between oppositely charged conductors. Electrically insulating the second rotor section **105b** from the first rotor section **105a**, and connecting the second rotor section **105b** to a constant voltage reference **140**, also contributes to signal isolation. These strategies minimize the corruption of the signal to be detected on the first rotor section **105a** by the signals S1, S2, S3, and S4, that sustain the mechanical oscillations of the rotor **105**. When an electric charge is applied to the device, an AC signal at the frequency shown for signal S5 in **Fig. 3** will be induced in the first rotor section **105a**, because this rotor section has a variable capacitance to the ambient. This AC signal, S5, is proportional to the electric charge on the apparatus and its phase with respect to signal S5 indicates the polarity of the electrostatic charge on the device.

To maximize the sensitivity of the electric charge detector **100**, the surface of the first rotor section **105a** can be covered with an array of sharp points to maximize the capacitance to the ambient. Sensitivity can also be improved by signal amplification **145** and filtering **150**.

Other arrangements of the movable plate electrode **105** and fixed plates **115**, **120** than those proposed, are possible. In a second embodiment of the invention, the variable capacitor is implemented by varying the surface texture of one electrode instead of variable area. This embodiment may be easier to implement using Micro
5 Electro Mechanical on Silicon (MEMS) technology. In this second embodiment, an array of ribbons, which form a smooth surface, yield a minimum capacitance in one position, and in another position, an array of sharp edges, yields a maximum capacitance. With this embodiment, only small movements are required.

In a third embodiment, a capacitance divider arrangement consisting of capacitance
10 to ambient in series with a variable capacitance to a floating ground of the device, also implies a small movement, since distance between conductors (tens of nanometers) rather than area can be modulated. A fourth embodiment is based on measuring the force of repulsion of like charges on two conductors. However, this embodiment has the disadvantage of its inability to yield polarity information of the electrostatic charge
15 on the object or body.

A fifth embodiment represents an alternative to signal amplitude measurement. In this embodiment, the electric field is neutralized to the ambient from the first rotor section **105a** using a wire grid **400** at the window in the faraday shield **200** as shown in **Fig. 4**. A voltage applied to this wire grid **400** with a voltage source **410** can be
20 adjusted to cancel the electric field to ambient resulting from an electrostatic charge applied to the electric charge detector. The neutralization voltage applied to the wire grid **400** is proportional to the electrostatic charge applied to the electric charge detector **100**. The output signal from the phase detector **135** can be used as an error signal to control the voltage used to null this error signal. This embodiment is more expensive in
25 MEMS technology as a result of the higher mechanical complexity. It has the advantage of greater precision, because the signal amplitude measurement is temperature sensitive due to parasitic capacitance, which is a significant fraction of the small capacitance (tens of nanofarads) to the ambient. This parasitic capacitance is temperature sensitive.

A typical application is illustrated in **Fig. 5**. The electric charge detector **100** could be mounted on a headband **700**, as shown in **Fig. 7**, to be worn by a person concerned about static charge buildup. Two ion generation wicks **710** are mounted on opposite sides of the headband (only one shown) to prevent ions from one wick from being collected on the other.

Another implementation of the present invention is shown in **Fig. 6**, wherein an ion generator is not used. The wristband **800** of **Fig. 8** would be a suitable fastener for this application.

In either **Fig. 5** or **Fig. 6**, the threshold generator **500** converts the analog output of the electric charge detector **100** to three (3) digital control signals: ">|THRESHOLD_A|", ">|THRESHOLD_I|", and "POLARITY". The first, ">|THRESHOLD_A|", is asserted when the electrostatic potential is dangerous to sensitive devices. The second, ">|THRESHOLD_I|", is asserted when the electrostatic potential exceeds the measurement resolution threshold. This second threshold is chosen to prevent excessive cycling on and off of the ion generators **510a**, **510b**, resulting in excessive power consumption. The third digital control signal, POLARITY, is asserted when a positive polarity of electric potential is present on the electric charge detector **100**. These three signals can be used to activate a sensory alarm **520** and/or to activate the appropriate polarity ion generator **510a**, **510b**.

The above embodiment is the preferred embodiment, but this invention is not limited thereto. It is, therefore, apparent that many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.